Over grazing and improper grazing techniques adjacent to Cascade Reservoir (right) have been replaced with proper grazing and reestablishment of riparian vegetation (left).

Compendium of Best Management Practices To Control Polluted Runoff

A SOURCE BOOK

Joan Meitl and Todd Maguire, Editors

March 2003

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Introduction

One source of pollution of our nation's waters is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural pollutants and pollutants resulting from human activity, finally depositing them into lakes, rivers, wetlands, and ground waters. In addition, hydrologic modification can also adversely affect the biological and physical integrity of surface waters.

The control of polluted runoff can be a complex process. Polluted runoff may originate from more than one type of land use and from many sources, and may include a variety of contaminants, transported by different delivery mechanisms. Each of these variables complicates the search for a set of practices that will provide a cost-effective solution. The effectiveness of many management practices is determined by a variety of factors such as land use, site conditions, cost, and maintenance requirements. The strategic choice and placement of the appropriate practices or systems of practices in the watershed are critical to their success in reducing the input of individual pollutants and improving water quality.

There are many sources of information for the wide variety of management practices that can be used to protect, maintain, or enhance water quality. Much of the information in this document has been adapted from information developed by the U.S. Environmental Protection Agency. While much information is available, finding the best set of management practices for a particular problem can be a time-consuming and confusing process. Knowing how to select the most appropriate practices from among the many options available further complicates the process.

The purpose of this document is to provide an overview of practices to control polluted runoff and a broad framework for selecting the appropriate practices for a specific situation. Many kinds of activities within a watershed are potential sources of polluted runoff. In this document, these activities have been divided into seven sectors: agriculture, silviculture, hydrologic modification, mining, urban/storm water runoff, transportation, and marinas and recreational boating.

This document is designed to help watershed managers, land treatment personnel, watershed advisory groups, and others interested in water quality to identify and select best management practices appropriate for their situations. This document can be used as a tool by local governments, governmental entities, nongovernmental organizations, and the general public in planning and implementing water quality programs.

The Compendium is designed to provide the reader with an introduction to the process of characterizing a water quality problem an overview of the types of practices that can be used for water quality protection or remediation, and a discussion of the factors that should be considered when selecting practices. The remaining sections of this document provide information about the following land and water use sectors:

- **SECTION 2** Agricultural Activities
- **SECTION 3** Silviculture Activities
- **SECTION 4** Hydrologic and Habitat Modification Activities
- **SECTION 5** Mining Activities
- **SECTION 6** Urban Activities/Storm Water Runoff
- **SECTION 7** Transportation Activities
- **SECTION 8** Marinas and Recreational Boating Activities

Included in each of these sections is an overview of the activities that can be sources of polluted runoff and the pollutants that they can potentially generate. The pollutants can potentially affect surface water and ground water. Both potential pathways must be considered in selecting the best approach to control pollution. Each section includes a discussion of the types of practices available to prevent or remediate pollution from the activities within that sector.

For each of the seven land and water use sectors, a list of pollutant control practices is provided in a table at the end of the section. These practices are organized by the category of activities to which they apply. For instance, biotechnical stabilization, a practice used to control sediment, is located under the subheading of Active Mining in the table for Mining Activities. The list of practices is not all-inclusive and does not preclude the use of other technically sound practices.

A definition of each management practice can be found in the glossary in Appendix A. When this document is viewed electronically, the reader can click on the name of a practice in each table and it will connect automatically to a description of the practice in the glossary. More detailed information about specific practices and their applicability can be found in other documents that are referenced in Appendix B. A hot link is provided to this information at the beginning of each table and can be accessed by clicking on "Additional Sources of Information." Most of this information can be accessed online. It can also be obtained by contacting the agencies listed in Appendix C.

Factors that affect the applicability of a practice include the targeted pollutants and the control mechanism of the practice (source control versus treatment). Each table is organized using these factors as column headings for which the definitions listed here are used.

TARGETED POLLUTANTS

- **Bacteria:** This category includes both bacteria and viruses.
- **Nutrients:** This category includes the two most common nutrients: nitrogen and phosphorus.
- **Dissolved Oxygen:** This category represents the activities and the most common substances in the form of organic matter that reduce the available oxygen in water.
- **Floatables:** The most common floatable materials are trash and yard waste. Floatable materials can also contain significant amounts of heavy metals, toxic chemicals, and bacteria.
- **Hydrocarbons:** This category includes petroleum-derived substances, particularly oil and grease that contain hydrocarbons.
- **Temperature:** This category includes thermal pollution problems that are a result of anthropogenic activities. Nonpoint sources include changes in channel or water body size, sediment, reduction in streambank and overstory vegetation, irrigation return flows, irrigation withdrawals, stormwater runoff, low flow, hydromodification, and unusually hot regional temperatures.
- **Toxics:** This category includes organic compounds such as pesticides, paints, solvents, adhesives, or other similar products and heavy metals such as lead, copper, cadmium, and zinc.
- **Sediment:** This category is the most common pollutant. Sediment can also carry other pollutants such as nutrients, toxic chemicals, and heavy metals.

MECHANISM: SOURCE CONTROL

- **Managerial/Operational:** Pollutant control through modification of behaviors, processes, or activities.
- **Good Housekeeping:** Pollutant control by keeping a clean site, through practices such as neat and orderly storage of materials, regular waste disposal, prompt cleanup of spills, and cleanup of sediments that have been tracked by vehicles or have been transported by wind or water about the site or onto nearby roadways.
- **Collection/Conveyance:** Pollutant control through the collection and/or transport of wastewater or runoff to minimize erosion, prevent contact with a pollutant, or provide treatment or discharge.
- **Containment:** Pollutant control through the collection and containment of runoff or wastewater for treatment or disposal.
- **Reduction/Elimination:** Pollutant control through the reduction or elimination of an existing or potential contaminant.
- **Protection:** Pollutant control through covering materials or wastes to prevent contact and dispersal by wind or water.
- **Stabilization:** Pollutant control through properly placing, grading, and/or covering soil, rock, or earth to ensure its resistance to erosion, sliding, or other movement.

MECHANISM: TREATMENT CONTROLS

- **Biological Treatment:** A treatment process in which biological activity removes or inactivates a contaminant.
- **Chemical Treatment:** A treatment process in which chemical interactions remove or inactivate a contaminant.
- **Filtration:** A treatment process in which suspended matter is removed from a liquid through a medium which is permeable to the liquid but not to the suspended material.
- **Infiltration:** A treatment process where the penetration of water through the ground surface into sub-surface soil removes contaminants from water by filtration, biological activity, absorption, or adsorption.
- **Sedimentation:** A treatment process in which soil particles, clays, sands, or other sediments that are carried by flowing water are deposited.

The tables at the end of Section 2-8 can be used in several ways. For instance, if the sector (land use) and targeted pollutants are known, the reader can refer to the table for that sector to identify specific activities that can contribute the targeted pollutants, practices may be applicable and their control mechanisms. When the objective is to minimize or prevent pollutants from a proposed activity, applicable control practices for the activity of concern can be found under the subheading in the table for the appropriate sector.

Problem Identification

One of the most critical steps in controlling polluted runoff is to correctly identify and document the existence of the water quality problem or potential problem. The water quality problem may be defined either as a threat or impairment to the designated use of a water resource. The diffuse nature of polluted runoff, and its spatial and temporal variability, makes it a difficult problem to treat. Pollutant sources can be difficult to identify and impacts may be subtle. Therefore, without adequate water quality problem documentation, polluted runoff cannot be successfully controlled.

The first step in identifying and documenting a water quality problem is to gather existing data on the water resource and the watershed. Water resource information may be gleaned from past or ongoing water quality studies and from land use, soil, hydrologic, and climatic data. This information will be needed to evaluate which practices will work given the local and regional conditions.

In cases where existing data are not adequate to identify or document a water quality problem, additional monitoring will be needed. The monitoring objective is to locate pollutant sources and ecological conditions contributing to the problem. The monitoring program must be designed such that at its conclusion a clear statement of the water use impairment(s), the primary pollutant(s), and the pollutant source(s) can be written.

After all pertinent preliminary water quality information has been obtained, and water quality data have been collected, a detailed water quality problem statement should be written. The water quality problem statement provides the basis for a strategy to effectively remediate or prevent water quality impairment and enhances the designated water resource use. The strategy is used to guide the selection and placement of practices designed to prevent, reduce, remediate, or retard specific pollutants. Clear problem identification and documentation should lead to a water quality problem statement that:

- Defines the water resource of concern;
- Delineates the water use impairment or threat of impairment and identifies its location and history; and
- States the pollutant(s), the pollutant source(s), and magnitude of the source(s).

Assumptions about the association between pollutants and impairments should be stated. In addition, any habitat attributes found to limit ecological health should also be included.

Water Quality Control Practices

Mechanisms to control existing or potential threats to water quality involve individual practices or systems of practices that address specific land uses, activities, pollutants, transport mechanisms, and/or management objectives.

Control practices use a variety of approaches that result in varying degrees of effectiveness. Practices can be temporary (e.g., for use during construction activity), permanent (e.g., detention pond) or managerial (e.g., record keeping).

Practices can be structural or nonstructural. Structural practices are manmade systems or devices designed to prevent or treat contamination. They may work by preventing leaks or water contamination, or stopping them at the source; collecting or diverting hazardous or toxic components of a waste stream; or encouraging filtration or infiltration of wastewater to allow natural processes to remove contaminants. Nonstructural practices work by changing behavior and may include such things as public education, land use controls, treatment requirements, and operating procedures.

Practices can be categorized as source controls or treatment controls, based on management objective. Source control is the first opportunity for control of any pollutant source. Source controls vary for different types of nonpoint source problems. They may or may not require construction. Examples of source controls include:

- Reducing or eliminating the introduction of pollutants to a land area. Examples include reduced nutrient and pesticide application.
- Preventing pollutants from leaving the site during land-disturbing activities. Examples include using conservation tillage, planning forest road construction to minimize erosion, siting marinas adjacent to deep waters to eliminate or minimize the need for dredging, and managing grazing to protect against overgrazing and the resulting increased soil erosion.
- Preventing interaction between precipitation and introduced pollutants. Examples include installing gutters and diversions to keep clean rainfall away from barnyards, diverting rainfall runoff from areas of land disturbance at construction sites, and timing chemical applications or logging activities based on weather forecasts or seasonal weather patterns.
- Protecting riparian habitat and other sensitive areas. Examples include protection and preservation of riparian zones, shorelines, wetlands, and highly erosive slopes.
- Protecting natural hydrology. Examples include pervious surface maintenance in developing areas (conditioned based on ground water considerations), riparian zone protection, and water management.

Treatment controls are practices for removing pollutants from contaminated runoff or wastewater before discharge. Treatment controls are generally structural in nature and do require maintenance. These practices intercept pollutants leaving the source prior to their delivery to the receiving water by capturing or infiltrating the runoff or wastewater, followed either by treating and releasing the effluent or by permanently keeping the effluent from reaching a surface water or ground water resource.

The performance of treatment controls is to a large extent dependent on suitable designs, operational conditions, and proper maintenance. For example, filter strips may be effective for controlling particulate and soluble pollutants where sedimentation is not excessive, but may be overwhelmed by high sediment input. Thus, in many cases, filter strips are used as pretreatment or supplemental treatment for other practices within a management system, rather than as an entire solution to a sedimentation problem.

Source controls are preferred over treatment controls for several reasons. Source controls are practices that prevent pollutants from entering a waterbody. Controlling pollutants at the source is more efficient and cost effective than removing them. In many situations, source controls can approach 100% effectiveness when implemented properly. Treatment control practices are rarely 100% effective, even if maintained and operated properly. There is also uncertainty as to the effectiveness and reliability of treatment control practices. Generally, source controls are less expensive than treatment controls and provide the most return for dollars invested.

The application of source and treatment control practices is dependent on site-specific conditions. Technical factors that may affect the suitability of management practices include, but are not limited to, land use, climate, size of drainage area, soil permeability, slopes, depth to water table, space requirements, type and condition of the water resource to be protected, depth to bedrock, and pollutants to be addressed.

There is often site-specific and regional variability in the selection of appropriate practices, as well as in the design constraints and pollution control effectiveness of practices. Factors to evaluate include the physical properties of the watershed (annual precipitation, soil type and drainage, ground water and surface water hydrology, and space limitations), land uses, and potential contaminants. Other criteria for determining what practice is best for a particular location might include the amount of pollution prevention or pollutant removal anticipated, the ease of implementing the practice, how much maintenance it will require, its longevity, the willingness of landowners to implement the practice (in a program of voluntary implementation, for instance), and its cost and cost-effectiveness. Practices must be economically feasible and well suited for the site.

When selecting practices, all costs must be considered, including labor and maintenance. Often a very effective practice will rapidly become a problem if all of the costs are not considered before implementation. The relative importance assigned to these and other criteria in judging what is best varies. Additionally, the choice of management practice is partially determined by the timeframe for the design, construction, and installation within the overall context of the associated activities.

Each structural and managerial practice used is part of a management practice system. Practices should be selected, designed, implemented, and maintained in accordance with site-specific considerations (e.g., slope, soil type, proximity to streams, and project layout) so they work effectively with the other management practices that form the system. This improves the ability of the practices to function together to achieve the overall management objectives. Final selection should be based upon the specific site conditions including land use activity, condition of receiving water, and types of pollutants present.

Examples of Best Management Practices (BMPs) Recently Implemented in the Field

The sections following each chapter of *Compendium of Best Management Practices to Control Polluted Runoff* showcase BMPs that were recently installed at field projects across Idaho. These projects, sponsored through DEQ's 319/Nonpoint Source Program are just a few of the many BMPs contained in this Compendium that may be applied to each of the seven sectors including:

Multi-Sector BMPs

Some BMPs related to roadways overlap into all seven sectors. These BMPs included actions like eradication of unneeded roadways, application of gravel to roadbeds, creation of truck friendly rolling water bars, and installation of fish friendly culverts. Other BMPs that can be used in any of the seven sectors include installation of properly sloped roadbeds, planting of grass, willows and dogwoods along waterways. Examples of BMPs are found at the end of each sector throughout the *Compendium.*

JERRY WEST, PHOTOGRAPHIC COMPILATION AUTHOR

Agricultural Activities

Agricultural runoff enters surface water through direct surface runoff or through seepage to ground water that discharge to a surface water outlet. The primary agricultural sources of pollutants are nutrients (particularly nitrogen and phosphorus), sediment, animal wastes, pesticides, and salts. Various farming activities result in the erosion of soil particles. The sediment produced by erosion can damage fish habitat and wetlands and, in addition, often transports excess agricultural chemicals resulting in contaminated runoff. This runoff in turn causes changes in aquatic habitats such as increased temperature and decreased oxygen. The most common sources of excess nutrients in surface water from polluted agricultural runoff are chemical fertilizers and manure from animal facilities. Such nutrients cause eutrophication in surface water. Pesticides used for pest control in agricultural operations can also contaminate surface as well as ground water resources. Return flows, runoff, and leachate from irrigated lands may transport sediment, nutrients, salts, and other materials. Finally, improper grazing practices in riparian and upland areas can also cause water quality degradation.

The land uses that comprise this sector include non-irrigated cropland, irrigated cropland, grazing land, animal waste management areas, and riparian/wetland areas. The practices that can be used to control agricultural pollutants control erosion and sediment, control discharges associated with animal facilities, manage nutrients and pesticides, control grazing impacts, and address water application on irrigated cropland.

Cropland, Non-irrigated and Irrigated

Activities associated with farming both non-irrigated and irrigated cropland can result in soil loss and the discharge of nutrients and pesticides. Practices to control polluted runoff from cropland can be used for both non-irrigated and irrigated cropland.

The problem associated with soil erosion is the movement of sediment and associated pollutants by runoff into a waterbody. Application of erosion and sediment control practices will reduce the mass load of sediment reaching a waterbody and improve water quality and the use of the water resource. Control can be achieved by using one of two different strategies or a combination of both. The first, and most desirable, strategy would be to implement practices on the field that would prevent erosion and the transport of sediment from the field. Practices that could be used to accomplish this are conservation tillage, contour strip-cropping, terraces, conservation cover, pasture planting and critical area planting.

The second strategy is to route runoff from fields through areas where control practices that remove sediment have been implemented. Practices that could be used to accomplish this are filter strips, field borders, grade stabilization structures, sediment retention ponds, water and sediment control basins, and terraces. Site conditions will dictate the appropriate combination of practices for any given situation.

Nutrient management practices are used is to minimize edge-of-field delivery of nutrients and minimize leaching of nutrients from the root zone. Nutrient management is achieved by developing a nutrient budget for the crop, applying nutrients at the proper time, applying only the types and amounts of nutrients necessary to produce a crop, and considering the environmental hazards of the site. In cases where manure is used as a nutrient source, manure-holding areas may be needed to avoid application to frozen soil.

Pesticide management practices are used to reduce contamination of surface water and ground water from pesticides. The most effective approach to reducing pesticide pollution of waters is, first, to release fewer pesticides and/or less toxic pesticides into the environment and, second, to use practices that minimize the movement of pesticides to surface water and ground water. Integrated pest management strategies should be used to minimize the amount of pesticides applied. In addition, pesticides should be applied efficiently and at times when runoff losses are unlikely. When pesticide applications are necessary and a choice of materials exists, producers should choose the most environmentally benign pesticide products. Users must apply pesticides in accordance with the instructions on the label of each pesticide product.

There are also practices that can be used on irrigated cropland to reduce polluted runoff from irrigation. These practices address irrigation scheduling, efficient water application, and the control of tailwater. The efficient transport of irrigation water, the use of runoff or tailwater, and the management of drainage water are additional considerations.

The seepage losses associated with canals and laterals can be reduced by lining the canals and laterals, or can be eliminated by converting open canals and laterals to pipelines. Flow-through losses will not be changed by canal or lateral lining, but can be eliminated or greatly reduced by converting to pipelines.

Well-designed and managed irrigation systems remove runoff and leachate efficiently, control deep percolation, and minimize erosion from applied water, thereby reducing adverse impacts on surface water and ground water. Additional surface drainage structures such as filter strips, field drainage ditches, and subsurface drains may also be used to control runoff and leachate if site conditions warrant their use.

Grazing Land

The focus of grazing management practices is on the riparian zone, however, the control of erosion from range, pasture, and other grazing lands above the riparian zone is also encouraged. Application of these practices will reduce the physical disturbance to sensitive areas and reduce the discharge of sediment, animal waste, nutrients, and chemicals to surface waters.

For any grazing management system to work, it must be tailored to fit the needs of the vegetation, terrain, class or kind of livestock, and particular operation involved. For both pasture and range, areas should be provided for livestock watering, salting, and shade that are located away from streambanks and riparian zones where necessary and practical. This can be accomplished by managing livestock grazing and providing facilities for water, salt, and shade as needed.

Appropriate grazing management systems ensure proper grazing use by adjusting grazing intensity and duration to reflect the availability of forage and feed designated for livestock uses and by controlling animal movement through the operating unit of range or pasture. Proper grazing use will maintain enough live vegetation and litter cover to protect the soil from erosion; will achieve riparian and other resource objectives; and will maintain or improve the quality, quantity, and age distribution of desirable vegetation. It may be necessary to improve or reestablish the vegetative cover on range and pastures to reduce erosion rates.

Providing water and salt supplement facilities away from streams will help keep livestock away from streambanks and riparian zones. The establishment of alternate water supplies for livestock is an essential component when problems related to the distribution of livestock occur in a grazing unit. Using the stream crossing technology to build a watering site can provide access to a developed or natural water supply that is protective of streambank and riparian zones. In some locations, artificial shade may be constructed to encourage use of upland sites for shading and loafing.

It may be necessary to minimize livestock access to streambanks, ponds, lakeshores, and riparian zones to protect these areas from physical disturbance. Fencing or establishing special use pastures to manage livestock in areas of concentration could also accomplish this.

Animal Waste

The problems associated with animal facilities result from runoff, facility wastewater, and manure. Practices that address these problems divert runoff water from upslope sites and roofs away from the facility, thereby minimizing the amount of water to be stored and managed. Runoff water and facility wastewater should be routed through a settling structure or debris basin to remove solids, and then stored in a pit, pond, or lagoon for application on agricultural land. For new facilities and expansions to existing facilities, consideration should be given to siting the facility away from surface waters, away from areas with high leaching potential, and in areas where adequate land is available to apply animal wastes in accordance with the nutrient management measure.

Animal waste practices also address the management of runoff from manure storage areas. Manure may be stacked in a confined lot or other appropriate area as long as runoff from the confined lot is controlled. If manure is managed as a solid, any drainage from the storage area, structure area, or structure should be routed to the runoff storage system. When applied to agricultural lands, manure, stored runoff water, stored facility wastewater, and accumulated solids from the facility should be applied in accordance with nutrient management practices.

It is recognized that implementation of this measure may increase the potential for movement of water and soluble pollutants through the soil profile to the ground water. Facility wastewater and runoff control systems can and should be designed to protect ground water. If soil conditions require further protection of ground water, protection can also be provided by minimizing seepage to ground water and by using the nutrient and pesticide management practices to reduce and control the application of nutrients and pesticides.

Riparian/Wetland Areas

Agricultural land use activities have the potential to degrade riparian habitats and wetlands. Livestock grazing is a significant contributor to streambank erosion and riparian habitat degradation. Problems associated with grazing included reduced riparian cover, exposed streambanks, high sediment levels, elevated water temperatures, higher nutrient levels, and a shifting to more stress-tolerant invertebrates.

Upland grazing management practices discussed above will protect water quality and aquatic and riparian habitats. Another practice that specifically protects riparian areas and wetlands is excluding livestock from sensitive areas such as streambanks, wetlands, estuaries, ponds, lakeshores, soils prone to erosion, and riparian zones. When exclusion is not practicable, livestock access can be minimized though the use of improved grazing management systems, installing alternative drinking water sources, installing hardened access points for drinking water consumption, and providing stream crossings.

Land and streambank stabilization practices can be used when damage to a wetland or riparian has already occurred. It may be necessary to improve or reestablish the vegetative cover on range and pastures or on streambanks to reduce erosion rates. Other practices such as planting channel vegetation, stabilizing stream channels and restoring wetlands can be employed when livestock has impacted a stream channel or wetland.

TABLE 1. Agricultural Practices

PRACTICE (NRCS Practice Code) *(ADDITIONAL SOURCES OF INFORMATION)*	**TARGETED POLLUTANTS** B bacteria F floatables N nutrients DO dissolved oxygen H hydrocarbons TP temperature T toxics S sediment	**MECHANISM** — **SOURCE CONTROL**							**TREATMENT CONTROL**				
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
NONIRRIGATED CROPLAND													
Alley Cropping (311)	N, S							✓			✓		
Contour Buffer Strips (332)	N, S						✓				✓		
Conservation Cover ((327)	N, S						✓	✓					
Conservation Crop Rotation (328)	N, S					✓							
Contour Farming (330)	N, S					✓							
Cover and Green Manure Crop (340)	N, S						✓						
Critical Area Planting (342)	N, S						✓						
Deep Tillage (324)	N, S												
Field Border (386)	N, S						✓						
Field Windbreak (380)	N, S						✓						
Filter Strip (393)	N, S										✓		
Grassed Waterway (412)	N, S							✓					
Mulching (484)	N, S						✓						
PAM Erosion Control (450)	N, S						✓	✓		✓			
Pasture and Hayland Planting (512)	N, S	✓											
Residue Management (329)	N, S						✓						
Sediment Basin (350)	N, S												✓
Stripcropping, Contour (585)	N, S					✓							
Stripcropping, Field (586)	N, S					✓							

continued

PRACTICE (NRCS Practice Code) *(ADDITIONAL SOURCES OF INFORMATION)*	TARGETED POLLUTANTS B bacteria, F floatables, N nutrients, DO dissolved oxygen, H hydrocarbons, TP temperature, T toxics, S sediment	MECHANISM											
		SOURCE CONTROL							TREATMENT CONTROL				
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
Nonirrigated Cropland (continued)													
Subsurface Drain (606)	N, S			✓									
Subsurface Drainage, Field Ditch (607)	N, S			✓									
Subsurface Drainage, Main or Lateral (608)	N, S			✓									
Surface Roughening (609)	N, S					✓		✓					
Terrace (600)	N, S					✓							
Underground Outlet (620)	N, S			✓									
Water and Sediment Control Basin (638)	N, S												✓
IRRIGATED CROPLAND													
Irrigation Canal or Lateral (320)	N, S			✓		✓							
Irrigation Field Ditch (388)	N, S			✓		✓							
Irrigation Land Leveling (464)	N, S			✓									
Irrigation Pit or Regulating Reservoir (552)	N, S				✓								
Irrigation Storage Reservoir (436)	N, S					✓							
Irrigation System, Sprinkler (442)	N, S					✓							
Irrigation System, Surface or Subsurface (443)	N, S					✓							

continued

PRACTICE (NRCS Practice Code) *(ADDITIONAL SOURCES OF INFORMATION)*	TARGETED POLLUTANTS B bacteria F floatables N nutrients DO dissolved oxygen H hydrocarbons TP temperature T toxics S sediment	MECHANISM											
		SOURCE CONTROL							TREATMENT CONTROL				
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
Irrigated Cropland (continued)													
Irrigation System, Tailwater Recovery (447)	N, S				✓								
Irrigation System, Microirrigation (441)						✓							
Irrigation Water Conveyance (428)	N, S				✓								
Irrigation Water Management (449)	N, S	✓											
Land Smoothing (466)	N, S					✓							
Lined Waterway or Outlet (468)	N, S			✓									
GRAZING LAND													
Brush Mgmt (314)	S							✓					
Channel Vegetation (322)	S, TP							✓					
Fencing (382)	S						✓						
Firebreak (394)	S						✓						
Forage Harvest Management (511)	S	✓											
Grazing Land Mechanical Treatment (548)	S					✓							
Heavy Use Area Protection (561)	B, N, S						✓						
Pipeline (516)	B, N, S			✓									
Prescribed Grazing (528)	B, N, S	✓											
Range Seeding (550)	B, N, S							✓					

continued

PRACTICE (NRCS Practice Code) *(ADDITIONAL SOURCES OF INFORMATION)*	TARGETED POLLUTANTS B bacteria, F floatables, N nutrients, DO dissolved oxygen, H hydrocarbons, TP temperature, T toxics, S sediment	MECHANISM													
		SOURCE CONTROL							TREATMENT CONTROL						
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
Grazing Land (continued)															
Spring Development (574)	B, N, S						✓						
Stock Trails and Walkways (575)	B, N, S					✓							
Streambank and Shoreline Protection (580)	N, S						✓						
Use Exclusion (472)	B, N, S						✓						
Water Harvesting Catchment (636)	B, N, S						✓						
Watering Facility (614)	B, N, S				✓		✓						
Closure of Waste Impoundments (360)	B, N				✓	✓		✓					
Composting Facility (317)	B, N					✓		✓	✓				
Dike (356)	B, N				✓								
Manure Transfer (634)	B, N			✓									
Roof Runoff Structure (558)	B, N					✓							
Waste Storage Facility (313)	B, N				✓								
Waste Treatment Lagoon (359)	B, N								✓				
Waste Utilization (633)	B, N					✓							
RIPARIAN/WETLAND AREAS													
Constructed Wetland (656)									✓		✓		✓
Fish Passage (396)													

continued

PRACTICE (NRCS Practice Code) *(ADDITIONAL SOURCES OF INFORMATION)*	TARGETED POLLUTANTS B bacteria F floatables N nutrients DO dissolved oxygen H hydrocarbons TP temperature T toxics S sediment	MECHANISM											
		SOURCE CONTROL							TREATMENT CONTROL				
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
Riparian/Wetland Areas (continued)													
Riparian Forest Buffer (391)	B, N, S, TP										✓		
Stream Channel Stabilization (584)	S							✓					
Stream Habitat Improvement and Management (395)	B, N, S, TP												
Tree/Shrub Establishment (612)	B, N, S, TP							✓					
Upland Wildlife Habitat Management (645)													
Wetland Restoration (657)													
Wetland Wildlife Habitat Management (644)													
GENERAL PRACTICES													
Access Road (560)							✓	✓					
Dam, Diversion (348)													
Diversion (362)	S			✓									
Grade Stabilization Structure (410)	S							✓					
Nutrient Management (590)	N	✓											
Pest Management (595)	T	✓											
Pond (378)													
Pond Sealing and Lining (521)					✓								

continued

PRACTICE (NRCS Practice Code) *(ADDITIONAL SOURCES OF INFORMATION)*	TARGETED POLLUTANTS B bacteria F floatables N nutrients DO dissolved oxygen H hydrocarbons TP temperature T toxics S sediment	MECHANISM											
		SOURCE CONTROL							TREATMENT CONTROL				
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
General Practices (continued)													
Prescribed Burning (338)	N, S	✓											
Pumping Plant for Water Control (533)	NA			✓									
Spoil Spreading (572)	S							✓					
Structure for Water Control (587)	NA			✓									
Water Well (642)													
Well Decommissioning (351)					✓								

AGRICULTURE SECTOR BMPS

Agriculture is the single largest nonpoint source contributor of sediment and nutrients to Idaho's surface water. Accordingly, there are numerous BMPs that are used almost exclusively for reduction of agricultural-related pollution. Some agriculture-related BMPs require education and close cooperation among farmers, ranchers, and numerous federal, state, and nonprofit organizations for implementation.

This sediment filter strip buffer has been graded in preparation for seeding. Previously, local farmers deep-tilled the land and planted wheat right up to the county road borrow ditch. This practice results in tons of sediment and nutrients being eroded, conveyed along the borrow ditch to tributaries and ultimately deposited into Winchester Lake. Once established (see photo on next page), this permanent grassy barrier will greatly reduce the amount of contaminants being transported to the lake.

▶ *In addition to the permanent filter strip buffers along highways, many farmers in Winchester Lake drainage area have agreed to start using no-till-farming techniques. At first glance this field might look like any other tilled field with furrows six to eight inches deep. But in reality this land has furrows that are only one to two inches deep. The net result is that the farmer saves time and fuel, production is increased, and there is much less erosion resulting in preservation of topsoil.*

▶ *This photo shows a small section of filter strip (foreground) buffering hundreds of acres of land that has been no-till farmed. These two BMPs result in greatly reduced erosion of sediment and nutrients into nearby Winchester Lake.*


NO MOTORIZED VEHICLES
OF ANY TYPE ALLOWED
PAST ROCK BARRIERS
FOR PUBLIC SAFETY AND
ENVIRONMENTAL RESTORATION

Silviculture Activities

Without adequate controls, silviculture operations may degrade waterbodies receiving runoff from forestlands. Sediment concentrations can increase due to accelerated erosion; water temperatures can increase due to removal of overstory riparian shade; slash and other organic debris can accumulate in waterbodies, depleting dissolved oxygen; and organic and inorganic chemical concentrations can increase due to harvesting, applying fertilizers and pesticides and oil and grease from equipment maintenance and operation. These potential increases in water quality contaminants are usually proportional to the severity of site disturbance.

The major silviculture activities that comprise this sector include timber harvest, road construction and management, forest regeneration, fire management, and chemical management.

Timber Harvest

Preplanning the timber harvest operation to ensure water quality protection can minimize polluted runoff and increase operation efficiency. Preharvest planning should include provisions to identify areas that may have merchantable trees, but pose unacceptable risks for landslides or high erosion hazard. Potential water quality and habitat impacts should also be considered when planning the harvest systems (even-aged versus uneven-aged) and planning the type of yarding system. Preharvest planning should address how harvested areas will be replanted or regenerated to prevent erosion and potential impact to waterbodies.

The planning of the streamside management area (SMA) width and extent is also crucial because of SMAs potential to reduce pollutant delivery. Careful planning of road and skid trail system locations will reduce the amount of land disturbance by minimizing the area of roads and trails, thereby reducing erosion and sedimentation. The proper design of drainage systems and stream crossings can prevent system destruction by storms, thereby preventing severe erosion, sedimentation, and channel scouring.

Streamside management areas are widely recognized to be highly beneficial to water quality and aquatic habitat. Streamside management areas need to be of sufficient width to prevent delivery of sediments and nutrients generated from forestry activities (harvest, site preparation, or roads) in upland areas to the waterbody being protected. Streamside management areas should be managed to maintain a sufficient number of large trees to provide for bank stability and a sustainable source of large woody debris. A sufficient number of canopy species should also be maintained to provide shading to the stream water surface needed to prevent changes in the temperature regime in the waterbody and to prevent deleterious temperature- or sunlight-related impacts on the aquatic biota.

The goal of planning practices and streamside management is to minimize sedimentation resulting from the siting and operation of timber harvesting and to manage petroleum products properly. Locating landings for both groundskidding and cable yarding harvesting systems according to preharvest planning minimizes erosion and sediment delivery to surface waters. Final siting of landings may need to be adjusted in the field based on site characteristics.

Ground skidding practices include skidding logs uphill to log landings whenever possible. Skid with ends of logs raised to reduce rutting and gouging. Skid along the contour and avoid skidding on slopes greater than 40 percent. Suspend ground skidding during wet periods, when excessive rutting and churning of the soil begins, or when runoff from skid trails is turbid and no longer infiltrates within a short distance from the skid trail. Retire skid trails by installing water bars or other erosion control and drainage devices, removing culverts and revegetating.

Landings and loading decks can become very compacted and are therefore a source of runoff and erosion. Practices that prevent or disperse runoff from these areas before the runoff reaches watercourses will minimize sediment delivery to surface waters. Proper closure of skid trails and landings will eliminate erosion in these areas. Practices can include water bars, scarification, seeding and/or obliteration.

Any chemicals or petroleum products spilled in harvest areas can be highly mobile, adversely affecting the water quality of nearby surface waters. Correct spill prevention and containment procedures are necessary to prevent petroleum products from entering surface waters. Designation of appropriate areas for petroleum storage will also minimize water quality impacts due to spills or leakage.

Road Construction and Management

Disturbance of soil and rock during road construction/reconstruction creates a significant potential for erosion and sedimentation of nearby streams and lakes. Proper road design and construction that are tailored to the topography and soils and that take into consideration the overall drainage pattern in the watershed can prevent road-related water quality problems. Road fill and road backslope failure, which can result in mass movements and severe sedimentation, can also be prevented.

Stabilizing back slopes and fill slopes as they are constructed is an important process in minimizing erosion from these areas. Combined with graveling or otherwise surfacing the road, establishing grass or using another form of slope stabilization can significantly reduce soil loss from road construction.

Proper road drainage prevents the concentration of water on road surfaces, thereby preventing road saturation that can lead to rutting, road slumping, and channel washout. It is especially important to ensure that road drainage structures are well constructed and designed for use during logging operations because the heavy vehicle use during harvesting creates a high potential for the contribution of large quantities of sediment to runoff.

The composition of a road surface is another factor that can be controlled to effectively control erosion from the road surface and slopes. Road surfaces can be formed from native material, aggregates, asphalt or other suitable materials and any of these surface compositions can be shaped with crowns, inslopes, and outslopes to promote drainage.

Sound planning, design, and construction practices often reduce the future levels of necessary road maintenance. Roads constructed with a minimum width in stable terrain, and with frequent grade reversals or dips, require minimum maintenance. Drainage of the road prism, road fills in stream channels, and road fills on steep slopes are the elements of greatest concern in road management. Roads used for active timber hauling usually require the most maintenance, and mainline roads typically require more maintenance than spur roads. The use of roads during wet or thaw periods can result in badly rutted surfaces, impaired drainage, and excessive sediment reaching waterbodies.

Inactive roads not being used for timber hauling are often overlooked and receive little maintenance. Older roads remain one of the greatest sources of sediment from forestland management. In some locations, problems associated with altered surface drainage and diversion of water from natural channels can result in serious gully erosion or landslides. Erosion problems may go unnoticed until after there is severe resource damage.

For these situations, there are road management controls that address maintenance of the roads and associated drainage systems. They also include provisions for road closure. Road closure involves preventing access by placing gates or other obstructions at road access points while maintaining the road for future use. Roads that will no longer be used or that have remained unused for many years may be decommissioned and obliterated. Decommissioning typically involves stabilizing fills, removing stream crossings and culverts, recontouring slopes, reestablishing original drainage patters, and revegetating disturbed areas.

Forest Regeneration

Regeneration of harvested forestlands not only is important in terms of restocking a valuable resource, but also is important to provide water quality protection from disturbed soils. Tree roots stabilize disturbed soils by holding the soil in place and aiding soil aggregation, which decreases slope failure potential. The presence of vegetation on disturbed soils also slows storm runoff, which in turn decreases erosion.

Leaving the forest floor litter layer intact during site preparation operations for regeneration minimizes mineral soil disturbance and detachment, thereby minimizing erosion and sedimentation. Mechanical site preparation can potentially impact water quality in areas that have steep slopes and erodible soils and in areas where the prepared site is located near a waterbody. Use of mechanical site preparation treatments that expose mineral soils on steep slopes can greatly increase erosion and landslide potential. Alternative methods, such as drum chopping, herbicide application, or prescribed burning, disturb the soil surface less than mechanical practices.

Mechanical planting using machines that scrape or plow the soil surface can produce erosion rills, which increase surface runoff and erosion. Natural regeneration, hand planting, and direct seeding are methods that can be used to minimize soil disturbance, especially on steep slopes with erodible soils.

Revegetation of areas of disturbed soil can successfully prevent sediment and pollutants associated with the sediment (such as phosphorus and nitrogen) from entering nearby surface waters. The vegetation controls soil erosion by dissipating the erosive forces of raindrops, reducing the velocity of surface runoff, stabilizing soil particles with roots, and contributing organic matter to the soil, which increases soil infiltration rates.

Fire Management

Fire management practices address prescribed fire for site preparation and stand maintenance as well as activities associated with wildfire control or suppression. Prescribed burning reduces slash, competition for nutrients among seedlings, and fuel for wildfires. Where tree species are ecologically dependent on fire for regeneration, fire also serves as an essential forest management tool. Prescribed burning must be properly managed to reduce soil disturbance during preparation for the burn and to limit the severity of the burn.

Wildfire suppression practices include avoiding of the use of fire-retardant chemicals over watercourses and remediating burned areas as soon as possible after the emergency is controlled. Other control practices include the proper location, design and closure of fire suppression components such as firelines, staging areas, helispots and camps.

Chemical Management

Chemicals used in forest management are generally pesticides (insecticides, herbicides, and fungicides) and fertilizers. Since pesticides may be toxic, they must be mixed, transported, loaded, and applied properly and their containers disposed of properly according to label restrictions in order to prevent potential polluted runoff. Since fertilizers may also be toxic or may shift the ecosystem energy dynamics, depending on the exposure and concentration, they must also be properly handled and applied. Oil, grease and antifreeze used for vehicle maintenance should also be stored, handled and disposed of properly.

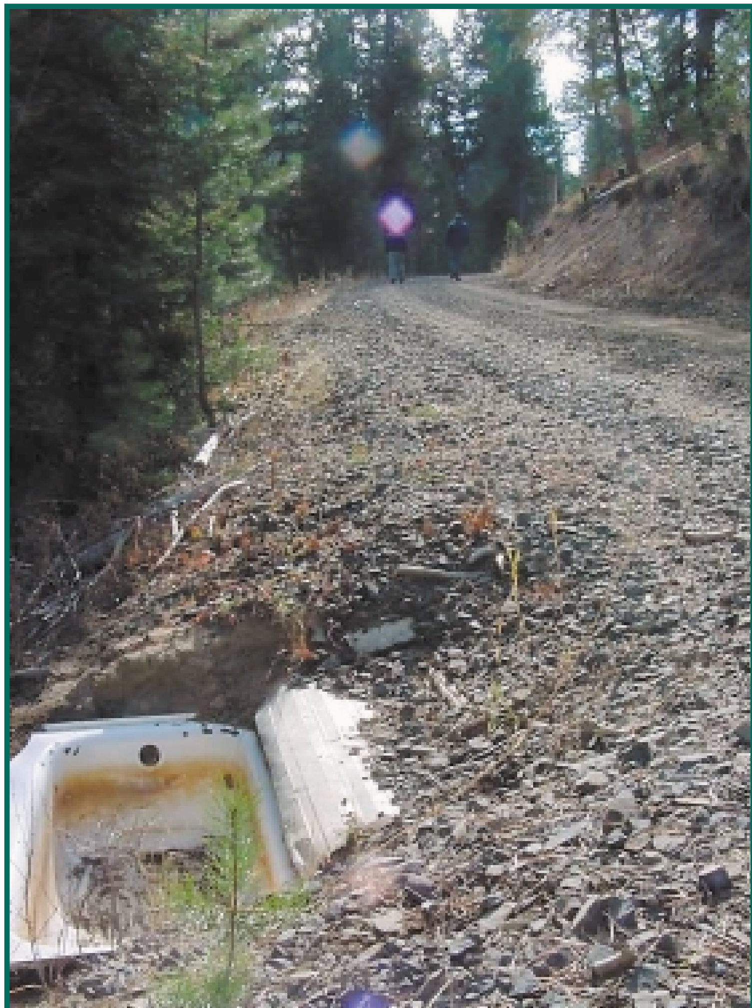
Pesticides and fertilizers can pose a risk to the aquatic environment depending on the application technique used. These chemicals can directly enter surface waters through five major pathways: direct application, drift, mobilization in ephemeral streams, overland flow, and leaching. The input from direct application is the most important source of increased chemical concentrations and is also one of the most easily prevented through proper application.

TABLE 2. Silviculture Practices

PRACTICE *(ADDITIONAL SOURCES OF INFORMATION)*	TARGETED POLLUTANTS B bacteria F floatables N nutrients DO dissolved oxygen H hydrocarbons TP temperature T toxics S sediment	MECHANISM											
		SOURCE CONTROL							TREATMENT CONTROL				
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
TIMBER HARVEST													
Harvest Planning	S	✓											
Road System Planning	S	✓											
Preharvest Notification	S	✓											
Streamside Management Areas	S, N, TP	✓											
Harvesting Practices	S					✓							
Landing Practices	S					✓							
Ground Skidding Practices	S					✓							
Cable Yarding Practices	S					✓							
Soil Protection	S						✓						
Winter Harvesting	S					✓	✓						
Petroleum Management	H	✓											
Waste Materials Treatment	S		✓										
ROAD CONSTRUCTION AND MANAGEMENT													
Scheduling	S	✓											
Soil Stabilization	S							✓					
Revegetation of Disturbed Areas	S							✓					
Runoff Collection and Conveyance	S			✓									
Runoff Dispersion and Dissipation	S					✓							
Sediment Collection	S												✓
Stream Crossings	S						✓						

continued

PRACTICE *(ADDITIONAL SOURCES OF INFORMATION)*	TARGETED POLLUTANTS B bacteria F floatables N nutrients DO dissolved oxygen H hydrocarbons TP temperature T toxics S sediment	MECHANISM											
		SOURCE CONTROL							TREATMENT CONTROL				
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
Road Construction and Management (continued)													
Road Maintenance	S					✓							
Drainage Structure Maintenance	S					✓							
Access Restriction	S						✓						
Revegetation	S							✓					
Winter Operation	S						✓						
Inactive Roads	S							✓					
Long-Term Inactive Roads	S							✓					
Permanent Road Closure	S							✓					
FOREST REGENERATION													
Site Preparation Practices	S						✓						
Residual Stocking	S						✓						
Regeneration Practices	S							✓					
Revegetation of Disturbed Areas	S							✓					
FIRE MANAGEMENT													
Prescribed Fire Practices	S, N						✓						
Wildfire Practices	S, N					✓	✓						
Fireline Practices	S, N					✓							
FOREST CHEMICAL MANAGEMENT													
Leak/Spill Prevention	H, T	✓											
Spill Contingency Plan	H, T				✓								



At the *Cascade Reservoir Watershed Roads and Forested Lands Project* located east and west of Cascade Reservoir, Valley County, Idaho the U S Forest Service, BLM, Idaho Department of Parks and Recreation and the Boise Cascade Corporation joined efforts to install a variety of BMPs. The project greatly reduces logging road sediment to 8.7 miles of road segments identified in the Cascade Reservoir TMDL. This is a high priority area in the forestry portion of the plan. Applications of these BMPs may be found in Tables 1, 2, 3, 4 and 6 of the Compendium. These BMPs include construction of logging truck (and other large vehicle) friendly rolling water bars, application of gravel, carefully sloped roadbeds, and eradication of unneeded roadways that contribute sediment to streams (photos on pages 25 and 26).

◀ *Prior to roadwork the 150-foot section of road shown in this photo contributed tons of sediment to Gold Fork Creek annually. This section of road was re-sloped, rolling water bars installed, and angular gravel applied. The bathtub was installed as a simple means of monitoring annual sediment runoff.*

▶ *The lower photo shows the annual total amount of sediment (less than one inch in depth) that was transported from the 150-foot section of road after the BMPs were installed.*

◄ *This is an example of a previous recreational road that was closed because it was a source of sediment erosion into Gold Fork Creek — a tributary to Cascade Reservoir. People now walk along this section of Gold Fork Creek but can no longer drive vehicles there. Applications of this BMP may be found in Tables 2, 3, 4, 6, and 7 of the Compendium.*

Hydrologic and Habitat Modification Activities

Hydromodification activities have been separated into the categories of channelization and channel modification, dams, and streambank and shoreline erosion. These categories include a wide variety of activities that impact instream and riparian habitat, wetlands, and streambanks.

One form of hydromodification is channel modification, which is river and stream channel engineering undertaken for the purpose of flood control, navigation, drainage improvement, and reduction of channel migration potential. Activities such as straightening, widening, deepening, or relocating existing stream channels and clearing or snagging operations fall into this category. These forms of hydromodification typically result in more uniform channel cross-sections, steeper stream gradients, and reduced average pool depths.

A frequent result of channel modification activities is a diminished suitability of instream and streamside habitat for fish and wildlife. They can also alter instream patterns of water temperature and sediment type, as well as the rates and paths of sediment erosion, transport, and deposition. Excavation projects can result in reduced flushing, lowered dissolved oxygen levels, loss of streamside vegetation, accelerated discharge of pollutants, and changed physical and chemical characteristics of bottom sediments in surface waters surrounding channelization or channel modification projects.

The term flow alteration describes a category of hydromodification activities that result in either an increase or a decrease in the usual supply of fresh water to a stream, river, or estuary. Flow alteration activities and structures include diversions, withdrawals, and impoundments. In rivers and streams, flow alteration can also result from undersized culverts, transportation embankments, sluice gates, and weirs.

Dams can adversely impact the hydraulic regime, the quality of the surface waters, and habitat in the stream or river where they are located. A variety of impacts can result from the siting, construction, and operation of dams. The siting of dams can result in the inundation of wetlands, riparian areas, and dry land upstream of the waterway. Dams either reduce or eliminate the downstream flooding needed by some wetlands and riparian areas. Dams can also impede or block migration routes of fish. Construction activities from dams can cause increased turbidity and sedimentation in the waterway resulting from vegetation removal, soil disturbance, and soil rutting.

The operation of dams can also generate a variety of types of pollution in surface waters. Dam operations may lead to reduced downstream flushing, which, in turn, may lead to increased loads of biological oxygen demand, phosphorus, and nitrogen; changes in pH; and the potential for increased algal growth. Lower instream flows, and lower peak flows associated with controlled releases from dams, can result in sediment deposition in the channel several miles downstream of the dam. The tendency of dam releases to be clear water, or water without sediment, can result in erosion of the streambed and scouring of the channel below the dam, especially the smaller-sized sediments. Finally, reservoir releases can alter the water temperature and lower the dissolved oxygen levels in downstream portions of the waterway.

Streambank erosion is a natural process that occurs in all fluvial systems, typically on large time scales. Streambank erosion can also be induced or exaggerated by human activities. Numerous factors within the watershed can contribute to anthropogenic streambank erosion in a given location. Three major causes of accelerated erosion related to human activity are channel modification, reservoir construction, and land use changes. Excessively high sediment loads that can result from streambank erosion can smother submerged aquatic vegetation beds, fill in riffle pools, and contribute to increased levels of turbidity and nutrients.

Channel Modification

Properly evaluating potential projects and reevaluating existing projects to ensure they reduce polluted runoff impacts and maximize potential benefits can help reduce impacts. Proper evaluation of channelization and channel modification projects should include examining existing and potential conditions and watershed management.

Existing channel modification projects can be evaluated to determine the impacts and benefits associated with the projects. Modifications to existing projects, including operation and maintenance or management activities, can also be evaluated to determine the possibility of improving some or all of the impacts without reducing the existing benefits or creating additional problems.

New channel modification projects that cause unavoidable physical or chemical changes in surface waters can also use one or more practices to mitigate the undesirable changes. The practices include streambank protection, levee protection, channel stabilization, flow restrictors, check dam systems, grade control structures, vegetative cover, instream sediment control, and setback levees or flood walls. By using one or more of these practices in combination with predictive modeling and restricting the timing of the activity, the adverse impacts of channelization and channel modification projects can be evaluated and possibly corrected.

Several structural practices are used in the protection or rehabilitation of eroded banks. These practices are usually implemented in combination to stabilize the stream system, and they can be grouped into direct and indirect methods. Direct methods place protective material in contact with the bank to shield it from erosion. Indirect methods function by deflecting channel flows away from the bank or by reducing the flow velocities to nonerosive levels.

Direct methods for streambank protection include stone riprap revetment, erosion control fabrics and mats, revegetation, burlap sacks, cellular concrete blocks, and bulkheads. Indirect methods include:

- Using dikes, wire or board fences, gabions, and stone longitudinal dikes
- Using hydraulic structures to stabilize stream channels, and to control stream sediment load and transport
- Using check dam systems, which provide sediment-reduction functions by trapping sediment behind the dams
- Using grade control structures, hydraulic barriers (weirs) installed across streams to stabilize the channel, control headcuts and scour holes, and prevent upstream degradation
- Planting vegetative cover alone or in combination with other structural practices.

There are several structural practices that can be used to control instream sediment depending on the management objective and the source of sediment. Streambank protection and channel stabilization practices, including various types of revetments, grade control structures, and flow restrictors, have been effective in controlling sediment production caused by streambank erosion.

Dams

Best management practices for dams should be undertaken individually or in combination to improve water quality and aquatic and riparian habitat in reservoir impoundments and tailwaters. They include:

- Using pumping and injection systems for reservoir aeration,
- Adjusting operational procedures at dams,
- Restoring or maintaining aquatic and riparian habitat, and
- Evaluating and managing the watershed.

One general type of pumping and injection systems uses pumps, air diffusers, or airlifts to induce circulation and mixing of layers of water. Another approach to improving water quality in tailwaters is aeration of reservoir releases through turbine venting, injection of air into turbine releases, installation of re-regulation weirs, use of selective withdrawal structures, or modification of other turbine start-up or pulsing procedures. A third group of approaches includes engineering modifications to the intakes, the spillway, or the tailrace, or the installation of various types of weirs downstream of the dam to improve temperature or dissolved oxygen levels in tailwaters. These practices rely on agitation and turbulence to mix the reservoir releases with atmospheric air in order to increase the concentrations of dissolved oxygen.

The quality of reservoir releases can also be improved through adjustments in the operational procedures at dams. These include scheduling releases or shortening the duration of shutoff periods, instituting procedures for the maintenance of minimum flows, and making seasonal adjustments in the pool levels and in the timing and variation of the rate of drawdown.

Several options are available for the restoration or maintenance of aquatic and riparian habitat in the area of a reservoir impoundment or in portions of the waterway downstream from a dam. One set of practices is designed to augment existing flows that result from normal operation of the dam. These include operation of the facility to produce flushing flows, minimum flows, or turbine pulsing. Another approach to producing minimum flows is to install small turbines that operate continuously. Installation of reregulation weirs in the waterway downstream from the dam can also achieve minimum flows. Finally, riparian improvements restore or maintain aquatic and riparian habitat in portions of the waterway affected by the location and operation of a dam.

Watershed management is also a valuable tool to reduce water quality problems in reservoirs and dam releases. Most polluted runoff problems in reservoirs and dam tailwaters frequently result from pollutants in the contributing watershed (e.g., sediment, nutrients, metals, and toxics). Good practices for watershed management include land use planning, erosion control, ground water protection, mine reclamation, pollutant source screening and identification, animal waste control, and failing septic tank control.

Another general watershed management practice involves the evaluation of the total watershed. This practice involves the evaluation of the sources of pollution in a watershed and determination of the most cost-effective combination of practices to reduce pollution among the various point and nonpoint sources.

Shoreline and Streambank Stabilization

Preservation and protection of shorelines and streambanks can be accomplished through many approaches, but nonstructural practices, such as soil vegetative bank stabilization ("bioengineering") and wetland creation are preferred. Other practices include structural practices, no-wake zones, and setbacks. Techniques involving wetland creation and bioengineering will usually be effective at sites with limited exposure to wave action. In other cases, the use of engineering approaches may need to be considered. In addition to controlling sediment sources that are causing pollution, these techniques can halt the destruction of wetlands and riparian areas located along the shorelines of surface waters. Once these features are protected, they can serve as a filter for surface water runoff from upland areas, or as a sink for nutrients, contaminants, or sediment already present in surface waters.

Bioengineering refers to the installation of living plant material as a main structural component in controlling problems of land instability where erosion and sedimentation are occurring. Soil bioengineering provides an array of practices that are effective for both prevention and mitigation of polluted runoff problems.

Wetland creation and restoration is another useful vegetative technique that can be used to address problems with erosion of shorelines. Wetland plants perform two functions in controlling shore erosion: dissipation of wave energy and added stability. The basic approach to erosion control is to plant a shoreline area with appropriate plant species.

Properly designed and constructed shore and streambank erosion control structures are used in areas where higher wave energy makes biostabilization and wetland creation ineffective. The most widely accepted alternative engineering practices for streambank or shoreline erosion control are fixed engineering structures, revetments, gabions, and groins. In areas where existing protection methods are being flanked or are failing, structural shore erosion control methods such as returns or return walls, toe protection, and proper maintenance or total replacements should be implemented. All streambank, shoreline, and navigation structures should be implemented so that they do not transfer erosion energy or otherwise cause visible loss of surrounding streambanks or shorelines.

No-wake zones can be established and enforced to reduce erosion potential from boat wakes. No-wake zones should be given preference over posted speed limits for reducing the erosion potential of boat wakes on streambanks and shorelines.

Another approach that should be considered in the planning process for shoreline and streambank erosion involves the designation of setbacks. Setbacks most often take the form of restrictions on the siting and construction of new standing structures along the shoreline. Upland drainage from development should be directed away from bluffs and banks so as to avoid accelerating slope erosion.

TABLE 3. Hydrologic Modification Practices

PRACTICE *(ADDITIONAL SOURCES OF INFORMATION)*	**TARGETED POLLUTANTS** B bacteria, F floatables, N nutrients, DO dissolved oxygen, H hydrocarbons, TP temperature, T toxics, S sediment	**MECHANISM**											
		SOURCE CONTROL							**TREATMENT CONTROL**				
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
HYDROMODIFICATION													
Streambank Protection	S						✓						
Levee Protection	S						✓						
Channel Stabilization	S							✓					
Flow Restrictors	S					✓							
Check Dam Systems	S							✓					
Drop Structure, Sills and Barbs	S							✓					
Grade Stabilization Structures	S							✓					
Vegetative Cover	S, TP						✓	✓					
Instream Sediment Control	S							✓					
Levee or Floodwall Setbacks	S						✓						
Restrict Timing of Activity		✓					✓						
DAMS													
Reservoir Aeration Sluicing Turbine Pulsing Turbine Venting Reregulation Weir	DO	✓											
Operational Adjustments	DO	✓					✓	✓					
Habitat Restoration and Maintenance (aquatic and riparian)	S, TP												
Flow Adjustments	DO	✓											

continued

PRACTICE *(ADDITIONAL SOURCES OF INFORMATION)*	**TARGETED POLLUTANTS** B bacteria F floatables N nutrients DO dissolved oxygen H hydrocarbons TP temperature T toxics S sediment	**MECHANISM**											
		SOURCE CONTROL							**TREATMENT CONTROL**				
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
Dams (continued)													
Small Turbines	DO					✓							
Watershed Practices	All	Practice dependent											
SHORELINE AND STREAMBANK STABILIZATION													
Bioengineering	S							✓					
Constructed Wetlands	N, S								✓		✓		✓
Dikes	S				✓		✓						
Structural Stabilization Practices	S							✓					
No-Wake Zones	S						✓						
Setbacks	N, S						✓						

At the *Winchester Lake & Upper Lapwai Creek Watershed Project* located near Grangeville, Idaho the Lewiston Soil and Water Conservation District, Nez Perce Tribe and Idaho Fish and Game worked together to install a variety of BMPS. Applications of this BMP may be found in all seven sectors (Tables 1-7).

◂ *This is an example of one of many new fish friendly culverts recently installed on tributaries to Winchester Lake.*

▶ *This photo shows grass, willows, and dogwoods that have been planted along an intermittent watercourse that drains into Winchester Lake. This new vegetation is greatly reducing the amount of sediment, nitrogen and phosphorous deposited in Winchester Lake. Applications of this BMP may be found in Tables 1, 2, 3, 4, 5 and 6 of the Compendium.*